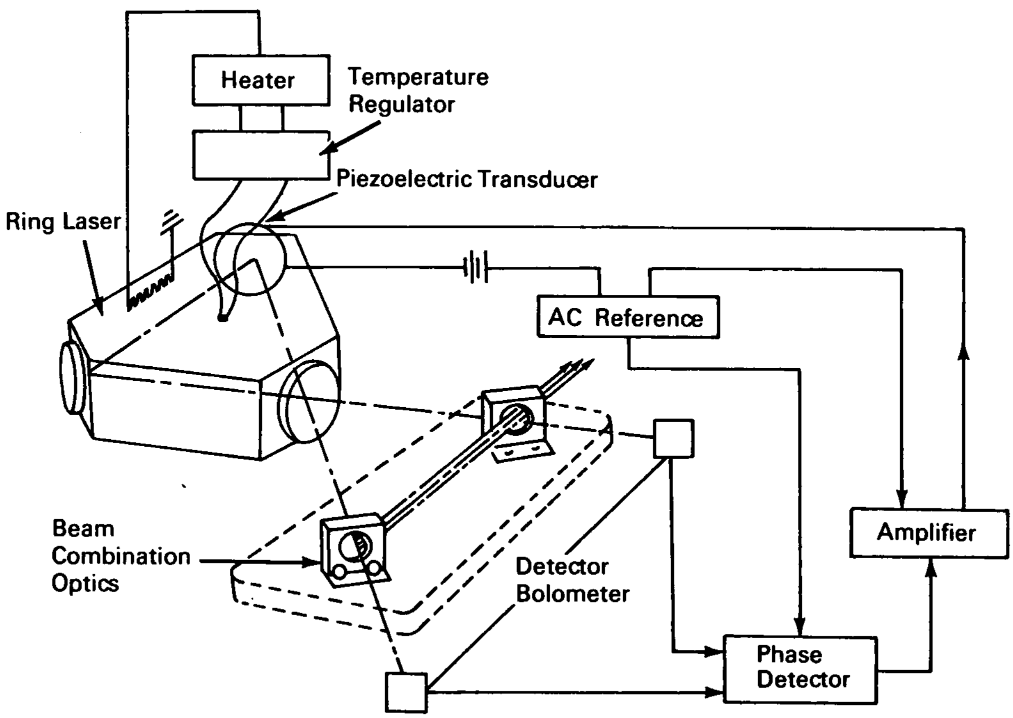
May 1967 Brief 67-10143

NASA TECH BRIEF

Design Concepts Using Ring Lasers for Frequency Stabilization



STABILIZED RING LASER USING PIEZOELECTRIC DITHER

Design concepts for laser frequency stabilization were evolved on the basis of theoretical and experimental work done in connection with a CO_2 laser research program. Several stabilization concepts were formulated and are described below. Each method is based on a frequency discriminant which generates an unambiguous deviation signal that can be used for automatic stabilization. Closed-loop control is used to stabilize cavity length at a null point which corresponds to the desired laser operating frequency. The approaches described here are:

(1) *Systems with a stabilized ring laser.* These systems have a frequency dithered ring laser as a stable element. Dithering is done either by a piezoelectric element or by a gain dither obtained through a discharge current dither. The frequency dither in the ring laser can be filtered from the system output by slaving a linear laser to the stabilized ring laser.

(continued overleaf)

(2) *Systems with a Doppler gain tube.* The gain tube is the reference for frequency deviations and a linear laser is locked to the frequency discriminant of the flow modulation.

These systems are described in greater detail below.

PIEZOELECTRICALLY DITHERED RING LASER

Stabilization using a ring laser depends on the clockwise (cw) and counterclockwise (ccw) beam competition resulting in a sharp switching action on beam intensity. This switching point occurs at a unique frequency and can be used as a frequency deviation reference.

The stabilization concept using a ring laser is shown above. The ring laser is dithered in frequency by applying a constant amplitude sinusoidal voltage to a piezoelectric element driving one mirror, and, thereby changing cavity length. The intensity modulated beam produces an ac signal at the detector output. The duty cycle (i.e., on–off time) of this signal varies with the laser operating point.

The control signal is derived from a phase sensitive demodulator which has as a reference the ac dither voltage. After amplification, the "dc" cavity stabilization signal is applied to the piezoelectric transducer to correct the cavity length. Operating as a null seeking system, the stabilization loop cancels out thermal and other disturbances occurring within its dynamic response capabilities. The stabilized output beam is obtained by combining both the cw and ccw beams of the laser.

FREQUENCY STABILIZATION USING DOPPLER GAIN TUBE

Frequency stabilization using a Doppler gain tube has the advantage that the modulation for purposes of frequency control can be done external to the laser, with negligible optical coupling back to the laser, itself. This approach (illustrated below) uses the gain modulation effect associated with the direction of gas flow in the gain tube to obtain a frequency discriminant. The gain modulation depth, and also phase (referred to the flow modulation frequency), depends on the laser operating point relative to the gain versus frequency profile in the Doppler gain tube.

To achieve stabilization, a portion of the output of the linear laser is directed into the gain tube. In the tube the flow of gas is modulated by solenoid valves to give a cyclic flow velocity $\pm v$ in the discharge. Upon passing through the gain tube, the laser radiation is modulated to a depth which depends on the laser operating point in frequency and the direction of gas flow. The signal from the thermistor bolometer is an ac voltage at the frequency of the flow modulation. Demodulation takes place in a phase sensitive demodulator operating with a reference derived from the solenoid valve modulation voltage. The amplified output of the demodulator is applied to the linear laser cavity to correct the length either to the piezoelectric element and/or to the heater.

Note:

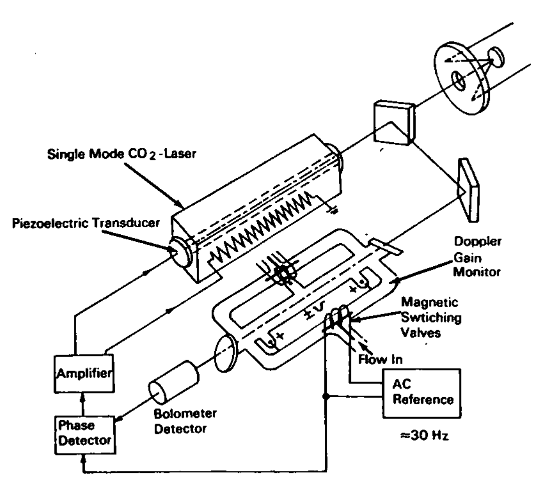
Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B67-10143

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. Mocker
of Honeywell Inc.
under contract to
Marshall Space Flight Center
(M-FS-2448)



FREQUENCY STABILIZED LINEAR LASER USING DOPPLER GAIN TUBE